REMARKS

Claims 1-34 are pending in the application. Claims 1, 21 and 22 have been amended.

In the Office Action, claims 1-7, 9-16, 20-25 and 28-29 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent 4,532,430 (Ross). Claims 1-7, 9-12, 15-23 and 30-34 29 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent 5,936,726 (Takeda) Claims 8 and 26 were rejected under 35 U.S.C. §103(a) as being unpatentable over Ross in view of U.S. Patent 5,399,867 (Kohno). These rejections are respectfully traversed. Applicants respectfully request reconsideration and allowance of the claims in view of the following arguments.

The present invention relates to an optical inspection apparatus and method that utilizes both linear and nonlinear optical phenomena to detect defects. In one embodiment of the present invention, shown in Fig. 1 of the application, a portion of the surface of an article, such as a semiconductor device W, is irradiated with a light beam 100a, such as a scanning laser at an incident wavelength. The light 100b emanating from the irradiated surface portion is then separated into light 100c at the incident wavelength and light 110d, 100e at one or more predetermined non-incident wavelengths, as by a diffraction grating 140, prism or filters. The light at the incident and nonincident wavelengths is sent to separate detectors 150a-c, such as photomultipliers (PMT), which respectively convert detected linear optical phenomena (scattered or reflected light at the incident wavelength) representing, e.g., surface topography, into an electrical signal; and convert detected nonlinear optical phenomena such as fluorescence, Raman scattering and/or second harmonic generation (resulting from light emanating from the irradiated surface at other than the incident wavelength) into electrical signals representing, e.g., chemical composition and material interfaces. The signal from each detector 150a-c is sent to a processor

170, which generates a defect map based on the information gleaned from both the linear and nonlinear optical phenomena.

Regarding the anticipation rejection of independent claims 1, 21, and 22 based on the Ross reference, these claims have been amended for clarity to recite that the first detector generates a first signal responsive to light at the incident wavelength, and that the second detector generates a second signal responsive to light at a wavelength different from the incident wavelength. Ross does not disclose or suggest the claimed second detector that generates a second signal responsive to light at a wavelength different from the incident wavelength, as required by amended claims 1 and 21, or the step of generating the second signal required by amended claim 22. Furthermore, Ross does not disclose or suggest the recited processor configured for, or step of, determining whether a defect exists on the inspected surface based on the first and second signals. These are important features of the claimed invention because, as discussed hereinabove, the detection and analysis of nonlinear optical phenomena (i.e., the light of the non-incident wavelength that emanates from the irradiated portion of the surface to be inspected) enables the inspection process to gather information relating to chemical composition and material interfaces in the sample.

Ross relates to a material inspection system wherein faults are detected by scanning the material to be inspected with a beam of light, and detecting the angular ranges into with the incident light is scattered by the faults with photodetectors (see Abstract). Ross does not detect or analyze light at wavelengths different from the incident wavelength, as claimed. Scattered light is simply light at the incident wavelength that is redirected into directions other than that of the incident beam after impinging on the inspected surface. There is nothing in Ross to even

suggest the detection or analysis of any light other than light at the incident wavelength emanating from the inspected material.

Thus, Ross does not anticipate independent claims 1, 21 or 22, because it does not disclose each and every element of those claims. Moreover, it would not have been obvious to add the claimed non-incident wavelength detection and analysis apparatus or process steps to the apparatus of Ross.

Consequently, independent claims 1, 21 and 22 are patentable over Ross, as are claims 2-7, 9-16, 20, 24, 25, 28 and 29, which depend from claims 1 and 22, respectively.

Further regarding dependent claims 9 and 27, despite the unsupported contentions to the contrary in the Office Action, Ross does not disclose or suggest that its second detector is for detecting Raman scattering. As explained in detail at page 5 of the present application, the well-known nonlinear optical phenomenon of Raman scattering occurs due to interactions between photons entering a material and other basic excitations in the material, such as vibrational excitations of its molecules, that result in the emission of "phonons". Raman scattering is a result of the interaction between a photon, which is a vibration of an electric field, and a phonon, which is a vibration of an atom at a specific frequency. In Raman scattering, the energy of a "Stokes-shifted" photon that emanates from a material (i.e., the scattered light) is equal to the energy of the photon entering the material less the energy of the excited phonon; in other words, the energy the entering photon gave up to the vibration of the phonon. This phenomenon is known as a "Raman shift" of wavelength and yields very sharp spectral lines, which is indicative of material properties of the inspected object.

Ross does not disclose detection of Raman scattering, as claimed. Ross detects scattered light at the incident wavelength only.

Consequently, claims 9 and 27 are further and separately patentable.

Further regarding dependent claims 10 and 28, despite the unsupported contentions to the contrary in the Office Action, Ross does not disclose or suggest that its second detector is for detecting second harmonic generation (SMG). As explained in detail at page 6 of the present application, the well-known nonlinear optical phenomenon of SMG occurs when two photons entering a material simultaneously excite an electron. The excited electron immediately relaxes, emitting a photon of twice the energy of a single photon. For example, two photons of 1eV each enter a material, and one photon of 2eV is emitted; that is, the emitted photon has a different wavelength than the incoming photons. SHG does not occur in the bulk materials commonly used in semiconductor manufacturing, such as bulk silicon and silicon dioxide, due to their crystalline symmetries. However, structures and interfaces break crystalline symmetries that prevent SHG. Therefore, SHG is useful in characterizing doping levels of silicon layers and interfaces between layers. In the methodology of the present invention, the presence or absence of SHG can be used to determine if a defect is present; e.g., if an interface is missing, expected SHG will be missing.

There is no teaching or suggestion in Ross of the detection or analysis of SMG. Consequently, claims 10 and 28 are further and separately patentable.

Regarding dependent claims 12-16 and 29, which respectively recite a separator for, and the steps of, separating light at the incident wavelength emanating from the irradiated surface from light at the non-incident wavelength and directing the light to respective detectors, since Ross does not teach detecting and analyzing light at a non-incident wavelength, Ross does not disclose or suggest the claimed separator or separating step. Ross's hologram 34, which is analogized in the Office Action to the claimed separator, is for deflecting and directing light of a

particular angular range, not for separating light of differing wavelengths (see col. 9:56 et seq. of Ross). Moreover, there is no showing in the Office Action that Ross's hologram 34 could separate light of different wavelengths, as claimed.

Consequently, claims 12-16 and 29 are further and separately patentable.

Further regarding dependent claim 20, which recites a processor configured to generate a defect map, Ross does not disclose or suggest such a processor. The passage of Ross cited in the Office Action in support of the Examiner's anticipation rejection of claim 20 does not discuss generating a defect map. Consequently, claim 20 is further and separately patentable.

Regarding the anticipation rejection of independent claims 1, 21, and 22 based on the Takeda reference, this reference does not disclose or suggest the claimed second detector that generates a second signal responsive to light at a wavelength different from the incident wavelength, as required by amended claims 1 and 21, or the step of generating the second signal required by amended claim 22. Furthermore, Takeda does not disclose or suggest the recited processor configured for, or step of, determining whether a defect exists on the inspected surface based on the first and second signals.

Takeda relates to a method for discriminating foreign particles on the surface of a sample from particles or defects within the sample. A light source is directed at the sample, light coming back from the sample is separated into polarized components, and optical detectors detect the polarized components. Takeda does not detect or analyze light at wavelengths different from the incident wavelength, as claimed. As discussed at col. 15:15 et seq. of Takeda, Takeda irradiates a sample to be inspected with polarized laser light, and the light reflected from the sample is polarized. Polarizing the reflected light (i.e., "sorting out" the vibrations in one particular direction) and detecting it, as taught by Takeda, does not imply that light of different

wavelengths is detected, as claimed. There is nothing in Takeda to even suggest the detection or analysis of any light other than light at the incident wavelength. In this respect, Takeda is a typical prior art inspection system discussed at pages 1-2 of the application, which gathers information relating to the topography of the sample using linear optical phenomena, but does not use nonlinear phenomena to gather other information (e.g., relating to the chemical composition of the sample, etc.), as does the present invention.

Thus, Takeda does not anticipate independent claims 1, 21 or 22, because it does not disclose each and every element of those claims. Moreover, it would not have been obvious to add the claimed non-incident wavelength detection and analysis apparatus or process steps to the apparatus of Takeda.

Consequently, independent claims 1, 21 and 22 are patentable, as are claims 2-7, 9-12, 15-20, 23 and 30-34, which depend from claims 1 and 22, respectively.

Further regarding dependent claim 9, despite the unsupported contentions to the contrary in the Office Action, Takeda does not disclose or suggest that its second detector is for detecting Raman scattering, as claimed. Raman scattering is a well-known optical phenomenon, as discussed hereinabove. Takeda detects scattered light at the incident wavelength only, and does not disclose or discuss detecting Raman shifts of wavelengths.

Consequently, claims 9 is further and separately patentable.

Further regarding dependent claim 10, Takeda does not disclose or suggest that its second detector is for detecting second harmonic generation (SMG). As explained hereinabove, SMG is a well-known nonlinear optical phenomenon. It has nothing to do with the angular difference between the incident light and the reflected light, as contended in the Office Action. There is no

teaching or suggestion in Takeda of the detection or analysis of SMG. Consequently, claim 10 is further and separately patentable.

Regarding dependent claims 12 and 15-17, which recite a separator for separating light at the incident wavelength emanating from the irradiated surface from light at the non-incident wavelength, and directing the light to respective detectors, since Takeda does not teach detecting and analyzing light at a non-incident wavelength, Takeda does not disclose or suggest the claimed separator. Takeda's polarization prism 6, which is analogized in the Office Action to the claimed separator, is for polarizing light reflected from the sample, not for separating light of differing wavelengths (see col. 15:24-33 of Takeda). Moreover, there is no showing in the Office Action that Takeda's prism 6 could separate light of different wavelengths, as claimed.

Consequently, claims 12 and 15-17 are further and separately patentable.

Further regarding dependent claim 20, which recites a processor configured to generate a defect map, Takeda does not disclose or suggest such a processor. The passage of Takeda cited in the Office Action in support of the Examiner's anticipation rejection of claim 20 does not discuss generating a defect map. Consequently, claim 20 is further and separately patentable.

Further regarding dependent claims 30-32, Takeda does not disclose or suggest irradiating a reference surface and analyzing the light reflected therefrom to determine if a defect exists, as required by these claims. Consequently, claims 30-32 are further and separately patentable.

Further regarding dependent claims 33 and 34, Takeda does not disclose or suggest analyzing light having a wavelength other than an incident wavelength, so Takeda cannot disclose or suggest determining that a defect exists by determining if a signal corresponds to a

wavelength other than the incident wavelength, as required by these claims. Consequently, claims 33 and 34 are further and separately patentable.

Regarding the obviousness rejection of dependent claims 8 and 26 based on Ross and Kohno, the Kohno reference does not furnish the teaching, missing from Ross, of a processor configured for, or the step of, determining whether a defect exists on the inspected surface based on two signals, one signal generated responsive to light at the incident wavelength and another signal generated responsive to light at other than the incident wavelength, as required by independent claims 1 and 22, from which claims 8 and 26 respectively depend. Therefore, any combination of Ross and Kohno would still be missing this important claimed feature, and it would not have been obvious to add this feature to any Ross/Kohno combination.

Consequently, claims 8 and 26 are patentable.

Reconsideration and withdrawal of the rejection of claims 1-34 under 35 U.S.C. §§102 and 103 are respectfully requested.

Accordingly, it is believed that all pending claims are now in condition for allowance. Applicants therefore respectfully request an early and favorable reconsideration and allowance of this application. If there are any outstanding issues which might be resolved by an interview or an Examiner's amendment, the Examiner is invited to call Applicants' representative at the telephone number shown below.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

MCDERMOTT, WILL & EMERY

Michael A. Messina
Registration No. 33,424

600 13th Street, N.W.
Washington, DC 20005-3096
(202) 756-8000 MAM:mcm
Facsimile: (202) 756-8087
Date: June 12, 2003